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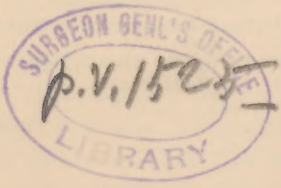

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THE HISTOLOGY OF THE SALIVARY GLANDS.

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Modern physiological research has imparted a new stimulus to histological investigations. For the fact is now well established that, in many tissues and organs, functional activity and rest, alternating, represent phases of life, each accompanied by distinctly recognizable morphological changes. No organs or class of organs have been more carefully, industriously, and, withal, ingeniously studied, in this direction, than the salivary glands. But, although abundant new evidence has thus been accumulated, it can not be said that the testimony of different authors has so far succeeded in harmonizing conflicting views and contending theories. It will be the aim of the writer to avoid theoretical and controversial reasonings as much as possible, and present the subject in its present aspect of real knowledge.

All the glands of this group belong to the compound acinous type. Here, at the very outset, we are confronted by the assertions of Grot and Klein, who positively declare that the salivary glands are exclusively made up of convoluted tubes. From the repeated examination of numerous specimens of different glands, the writer is satisfied that the acinous preponderates very decidedly over the tubular form, and hence it is more correct to class them under the former category.

It may also be mentioned, in this connection, that Bermann has described the normal occurrence of a compound tubular mucous gland found in intimate relationship with the submaxillary of man and several animals. Heidenhain, however, has demonstrated that

the organ described by Bermann really corresponds to the sublingual gland.

The salivary glands lie inclosed in a connective-tissue capsule of varying thickness. From this envelope trabecles are given off, and, traversing the organ in all directions, divide it into secondary lobes and lobules. In this supporting frame-work leucocytes are found in greater or less abundance, surrounding the interlobular ducts and vessels. In addition, large plasma cells (Waldeyer), or Ehrlich's corpuscles (*Mastzellen*), are commonly encountered. The excretory ducts form a system of ramifying tubes, terminating in the secreting acini or vesicles.

Each acinus consists of a *membrana propria* (basement membrane) lined by a varying number of secreting cells. In fresh specimens derived from animals recently killed, the membrana propria invariably appears as a very delicate, translucent, and apparently structureless membrane. In sections of hardened glands, flattened oval nuclei are found studding it.

Boll, Heidenhain, Lavdovsky, and, in fact, most recent authors, assert that the membrana propria is composed of flat, branching cells, which form a basket-like reticulum, containing the secreting corpuscles. The writer can not concur in this view. Branching nucleated bodies of the kind described by these authors are, indeed, readily visible after suitable modes of preparation. But they usually lie outside of the membrana propria, being superimposed to afford the necessary additional strength to this extremely delicate membrane. Pflüger described them as multipolar ganglion cells. But his views are clearly erroneous, having been refuted by all later investigators, with but few exceptions. One of these, Kupffer, claims to have succeeded in demonstrating the direct entrance of nerve fibrils into the glandular acini in the cockroach (*Blatta orientalis*). But even this author failed to corroborate the assertions of Pflüger with regard to man and the higher animals.

According to the observations of the author, the membrana propria is a nucleated connective-tissue membrane. In the fœtus it is first formed in the following way: Solid proliferating plugs of epithelia, representing the future parenchyma, grow into the surrounding embryonic tissue. The layer of connective-tissue cells immediately adjoining the epithelia gradually assumes a flattened shape. At length these corpuscles coalesce and form a richly nucleated membrane. In later life some of the nuclei atrophy and disappear, but a certain number usually persist. For this reason the membrana propria in adult glands appears as a homogeneous membrane, containing a varying number of nuclei. The branched cells

are superimposed, or lie beneath it; but, while they are found to adhere to it, they, nevertheless, do not form true constituent elements of the membrane in question.

The epithelia of the proper gland substance usually line the basement membrane, in a single layer of nucleated, pyramidal, cuboidal, or polyhedral cells. In structure they differ rather widely in the various glands belonging to this group. It will be well, therefore, to consider, separately, first the cells of the albuminous glands, and then those of the mucous type.

1. *Albuminous Glands.*—Formerly these were known as "serous" glands, since the product of their secretion was apparently a serous fluid. Recently, however, Heidenhain has demonstrated the abundant presence of albuminoid matter therein. Glands of this type are, therefore, more properly called albuminous. The parotid gland of man and mammals generally, the lachrymal glands, the submaxillary glands of certain animals, and the larger portion of the human submaxillary gland, are included in this category.

In fresh specimens the cells of their alveoli appear to be so completely filled up with darkly granular matter that their boundaries are either invisible or quite obscure. Sections of hardened glands, however, show the intercellular boundary lines clearly marked. The form of these corpuscles is now seen to be either somewhat rounded or polygonal. Each one is, as a rule, provided with a pale, spherical nucleus, occupying a peripheral position—i. e., approaching the membrana propria. In hardened specimens of resting glands, the nuclei commonly assume a stellate or angular form, the result of shrinkage. As regards the size of the salivary epithelia, their average diameter is 0·015 mm., the nuclei measuring 0·006 mm. It should be borne in mind, however, that many cells fall considerably below this average, whereas others measurably exceed it.

2. *The Mucous Glands.*—In the simplest glands of this type the alveoli contain a single layer of large, clear, transparent, columnar cells, almost identical in appearance with the so-called goblet cells of the alimentary canal. In recent specimens the nucleus is found round or oval, but in hardened glands it appears quite flat. In all cases it almost lies in contact with the membrana propria.

But the glands of this variety contain, in addition to the simple mucous cells just described, smaller and very granular bodies, which are known as the *crescents*, or *lunulæ*, of Giannuzzi. They usually occur in semilunar groups, and are found external to the mucous cells, and just beneath the basement membrane. The individual cells of such groups are not always provided with a nucleus. In some, however, two nuclei appear.

Isolated mucous cells (maceration of fresh gland in iodized serum or chromate of ammonium) appear to be furnished with a distinct cell-membrane. A protoplasmic process also juts out from the vicinity of the nucleus. While in situ these processes are placed in apposition to the membrana propria. They become deeply tinged in stained specimens. The contents of these mucous cells is a clear substance, containing a few granules, and giving the characteristic micro-chemical reactions of mucin.

As regards the granular crescents, their behavior under the application of different chemical reagents leaves no doubt as to the albuminoid nature of their cell-substance. There is an infinite variety in the proportion of albuminous cells to crescents. For we find in some glands a very marked preponderance of one variety of corpuscular elements over another, whereas in others they are about equally distributed.

Having thus briefly indicated the characteristic appearances of the cellular constituents of the alveoli, as found in glands which had been at rest before being examined, we are now prepared to appreciate the *morphological changes occurring in the active organs.*

In the quiescent state of the gland, then, the protoplasm of its alveolar cells is gradually converted into a material resembling the ultimate product of secretion. It is but natural, therefore, to find in gland cells which have enjoyed prolonged rest a small proportion of protoplasm. In fact, as has been already stated, the quiescent gland is marked by the coarsely granular appearance of the secreting corpuscles, and by a more or less complete obscurity both of cell-boundaries and of nuclei. In the mucous glands this is due to the abundant presence of mucigenous material, destined subsequently to become converted into mucin.

But let a proper stimulus now waken the dormant activity of the gland, and interesting changes are at once inaugurated. The cells gradually lose their granular aspect, distinct boundary-lines become visible, and the nucleus appears. In glands exhausted by protracted secretion or excessive stimulation, we accordingly find conspicuous nuclei, shrunken alveolar corpuscles, and small granular cells closely resembling the crescents of Giannuzzi. The entire alveolus appears reduced in size. At length, in typical mucous glands, the large, clear, mucous cells are found to have entirely disappeared. Heidenhain and his followers have concluded, from these easily demonstrable and constantly recurring phenomena, that the mucous cells suffer actual destruction, and that restitution of the alveolar epithelium occurs in consequence of proliferation of the parietal cells.

The writer can not accept this interpretation. His own observations point to the probability that actual disintegration of the secreting cells occurs only under pathological conditions. The mucous cells disgorge the mucin which has been formed within them by protoplasmic metamorphosis, they alter their appearance considerably, but nevertheless they continue to exist. It is by a constant renewal of their protoplasm that they are thus able to secrete for a period of indefinite length. Destruction and recuperation, growth and decay, are thus constantly taking place at the same time and in the same gland.

Turning our attention now to the excretory channels, we find that the lobar and larger interlobular ducts have essentially the same structure. That is, they consist of a basement membrane lined with a double layer of large columnar cells, and surrounded by a varying amount of connective tissue. The nucleus is oval and sharply defined, and it is generally found in the middle of the cell. A longitudinal striation is often distinctly seen in these epithelia, giving them the appearance of being traversed by minute rodlets. Lateral anastomoses have been described between these rodlets by Klein. In fact, this author finds networks of various kinds in all the cellular constituents of glands, and even in most nuclei. But his assertions in this respect are not confirmed by most recent authors, and certainly in fresh specimens such reticula are conspicuously absent. When they do occur it seems that they are but the anatomical expression of protoplasmic coagulation.

The interlobular ducts or salivary tubes (*Speichel-Röhren*) of Pflüger have only a single layer of columnar epithelia, the external portion of which (that nearest the basement membrane) is characterized by longitudinal fibrillæ, or rods. At about the middle of each cell there is a large round or oval nucleus.

Between the interlobular ducts of larger caliber and the alveoli there is found still another variety of excretory channels. These are the intermediate or intercalated ducts. They are lined with relatively long, spindle-shaped corpuscles (parotid gland), or small, cuboidal cells (submaxillary of different animals).

Quite recently Klein has also described "a distinct, narrow, short bit," found intermediate between the salivary tubes and the intercalated part. This he calls the neck, and points out the similarity of such an arrangement to the transition of the duct into the alveolus of the pyloric glands.

A structure of this kind is indeed often seen, but it is also frequently absent, so that we are not justified in regarding it as a constant anatomical feature. Finally, the presence of smooth

muscle fibers in the main ducts is a fact which deserves to be mentioned.

From an examination of the blood-vessels and lymphatics we learn that a beautiful and dense capillary plexus surrounds the acini of the salivary glands. But the vascular walls are not in immediate contact with the membrana propria, being separated therefrom by lymph-spaces. When the latter contain much fluid, the distance between capillary wall and basement membrane will thus be materially greater than when only a small amount of liquid is present in these lymph-channels. The arteries and veins are devoid of peculiarities deserving of special mention.

In addition to the circumvascular lymphatics, just described, there are found channels around the ducts and acini. Both sets of vessels are connected, however, by abundant anastomoses. Valves are present in these lymph-vessels, and lateral pouches corresponding to them. This gives rise to a sacculated appearance, which is so characteristic of their course.

Medullated nerve-fibers are readily seen to enter the salivary glands at the hilus. They follow the course of the main duct, forming a plexus around its larger ramifications. From this reticulum, which is provided with collections of ganglia of varying dimensions, secondary medullated fibrils arise, and are distributed between the smaller lobules. Ganglion cells, but of smaller size, are still found here. Non-medullated fibers are at length given off from the other nerves, and may be traced to the acini. But concerning their terminal distribution we have as yet no definite knowledge; only a number of more or less acceptable statements and theories.

Most conspicuous among these is Pflüger's, because couched in words of most positive assurance. Briefly stated, this author regards the secreting cells as the real nerve terminations. And he bases this conviction on what he claims to have actually seen, viz., the direct entrance of axis-cylinders into the glandular epithelia.

But, with a few exceptions, presently to be mentioned, all recent observers have failed to corroborate Pflüger's assertions. These exceptions are Patenko, who claims to have seen nerve-endings in the uterine glands; Kupffer, who, as already stated, saw similar terminations in the so-called salivary bodies of the cockroach; and Openchowski. The latter asserts that, in the glands of the nictitating lid of frogs, he has discovered unmistakable evidence of the direct entrance of nerve-fibrils into secreting epithelia. Such fibers, he says, are continuous with an intracellular reticulum.

Finally Palladino, ten years ago, described somewhat similar appearances.

It does not seem desirable to enter more fully into the various details of pending controversies concerning the termination of nerves in the salivary glands. What has been briefly described is what we actually see, and not the imaginary pictures drawn by enthusiastic observers.

Intra-alveolar networks and capillary secreting ducts have been very minutely described by different authors. As regards the latter there can be no doubt that an albuminoid intercellular cement-substance, which may be displaced by any fluid injected with sufficient force into the main duct, has given rise to appearances simulating the existence of minute channels between the secreting cells. In the light of our present knowledge it may be definitely asserted that capillary excretory ducts, possessed of walls of their own, do not constitute real structural features of the salivary glands.

The same also applies to the reticulum which many have asserted to exist within the acini of all these glands. Protoplasmic coagulation, resulting from the different hardening processes and methods of preparation, must be held accountable for the net-like appearance referred to. In the living gland such a reticulum is not found.

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